

Verification of Frontal Lobe Activity by Bilateral Arm Coordination Japanese Daily Activities

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Summary

Dementia prevention is a significant concern in an aging Japanese society. Consequently, to investigate daily activities that elicit heightened frontal lobe activity, electromyography (EMG) and electroencephalography (EEG) measurements were conducted on tasks involving repetitive, distinct movements of the left and right upper arms. These tasks included tamagoyaki preparation, egg cooking, calligraphy, and fish preparation, which are activities familiar to the Japanese population. Activities of daily living with sustained activity in the frontal lobe were examined.

Introduction

The prevalence of dementia in Japan continues to increase. It is estimated that the total number of dementia patients aged 75 and over in Japan will reach 18% in 2025. Consequently, interventions to prevent dementia are considered necessary. The objective of this study was to examine the learning process and frontal lobe activity through repetitive training of a bilateral arm coordination exercise involving a few familiar tasks.

Methods

The experiment was designed to examine frontal lobe activity through bilateral arm coordination exercises [1] and was conducted using three items: calligraphy, tamagoyaki, and fish-skimming (Figure 1). Seven female students ($M \pm SD$, age 20.30 ± 0.5 years, height 157.4 ± 3.9 cm, weight 47.6 ± 6.4 kg) and nine male students ($M \pm SD$, age 20.30 ± 1.2 years, height 172.2 ± 4.5 cm, weight 65.2 ± 9.7 kg) participated in this experiment as volunteers. Only subject F was left-handed, and all participants had minimal experience with experimental work. The protocol was approved by the local ethics committee (H2023-11). Subjects' surface electromyographic activity of the brachial radius and biceps brachii muscles of both the left and right arms was recorded while performing their respective experiments using two pre-gelled 10 mm Ag-AgCl monopolar electrodes. Electrodes were placed along the mid-sagittal axis of the muscle. Prior to the placement of the electrodes, the skin was shaved, and the recording sites were gently abraded using abrasive gel and cleansed using alcohol swabs to reduce inter-electrode impedance below 5 K. Additionally, a sensor device for three-dimensional accelerometry was placed on the dorsal surface of their right hand. Raw EMG was acquired at a sampling frequency of 500 Hz. EEG was acquired using an EEG-Cap with 22 channels.

Following EEG data recording, a topology map was calculated using EMSE (Cortech Solutions, INC).

Results and Discussion

All three activities become familiar through mastery; however, EEG activity in the frontal lobe remains active. Furthermore, the learning effect is more pronounced with increased repetition of the activity. Consequently, the necessity for developing rehabilitation programs is evident, given the rising incidence of stroke and dementia patients, as well as the significance of motor movements involving both hands. The findings indicated that standing tamagoyaki preparation and fish slicing elicited greater stimulation compared to seated calligraphy.



Figure 1: Three experimental settings, calligraphy, tamagoyaki, and fish-skimming with EMG and EEG.

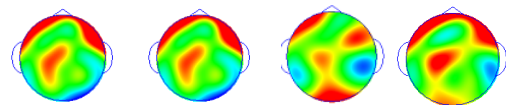


Figure 2: Typical response in tamagoyaki egg cooking during activity of both arms with the right and left hand performing separate actions.

Conclusions

In instances of repetitive movements, EEG responses were often absent or minimal; however, when the left and right arms were utilized to perform distinct voluntary movements, frontal lobe activity was observed.

Acknowledgments

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References

- [1] Atsushi Yokoi, Masaya Hirashima, Daichi Nozaki. (2011). Gain-field encoding of the kinematics of both arms in the internal model enables flexible bimanual action *Abbrev. The Journal of Neuroscience* 31(47)17058-17068